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Estimation of correlation length of InSAR data error based on ABIC: Importance of modeling error in seismic source inversion

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InSAR data provide the most important information in estimating fault slip distribution of relatively large shallow earthquakes. When fault geometry is unknown, a common strategy for obtaining slip distribution is to first determine the fault geometry under the assumption of a uniform slip on a rectangular fault, and then apply the usual linear inversion technique to estimate slip distribution on the determined fault. However, this method is complicated and time consuming. Furthermore, the determined fault may not be the best for a spatially variable slip distribution.
Although the inverse problem is non-linear for unknown fault geometry, the non-linearity of the problem is weak when we can assume the fault to be a flat plain. Taking it into account, Fukahata and Wright (2008) developed an inverse method to estimate slip distribution by regarding the parameters to determine the fault geometry as hyperparameters as well as the smoothing parameter. The optimal values of the hyperparameters are objectively determined from observed data by minimizing ABIC (Akaike's Bayesian Information Criterion). Another important point of Fukahata and Wright (2008) is the introduction of covariance of InSAR data, which solved the problem that the solution depend on the sampling rate of InSAR data.
The method of Fukahata and Wright (2008) has been applied to several earthquakes such as 1995 Dinar earthquake, 2008 Iwate-Miyagi Nairiku earthquake (Fukahata et al., 2008), and 2010 Haiti earthquake (Hashimoto et al., 2010). In these analyses, however, shallower dip angles (by about 10 degrees or more) were usually obtained in comparison with the dip angles estimated from seismic data. Such systematic difference suggests that the inverse method may have an significant defect.
In Fukahata and Wright (2008), the correlation length s of error is set to 10 km based on the analysis of InSAR data error (Wright et al., 2003). Recently, not fixing s at 10 km, we reanalyzed InSAR data of Dinar earthquake. Then, we found that ABIC became the minimum around s = 1 km and much larger for s = 10 km. This means that s = 1 km is a better model than s = 10 km.
It is interesting that the optimal correlation length (1 km) is much shorter than 10 km expected from observation error. The reason of this discrepancy must be due to modeling error. In general, the error e in the observation equation, d = Ha + e, is the sum of observation error and modeling error. If the modeling error is much larger than the observation error and if the correlation length of the modeling error is about 1 km, the above result is consistently explained.
Furthermore, we found that the optimal dip angle changed from 34 degrees to 42 degrees in response to the change of the error correlation length s from 10 km to 1 km. Here, it should be noted that the value of 42 degrees is perfectly consistent with the estimate from seismic data (Wright et al., 1999). Thus, we succeeded in solving the discrepancy between InSAR and seismic data analyses by regarding s as another new hyperparameter.